CALIFORNIA DIVISION OF MINES AND GEOLOGY
FAULT EVALUATION REPORT FER-235
***** SUPPLEMENT No.1 *****

THE SAN GORGONIO PASS, BANNING AND RELATED FAULTS
Riverside County, California

by
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May 15, 1995

INTRODUCTION

This is a supplement to FER-235 (Treiman, 1994). This supplement has been prepared to respond to comments received regarding the Preliminary Earthquake Fault Zone maps for the Beaumont, Cabazon, El Casco and Whitewater 7.5-minute quadrangles (Calif.Public Resources Code, Div. 2, Chapt. 7.5, sec.2622(c); see Hart, 1994, appendix A). Written comments were received from the California Department of Water Resources, California Institute of Technology, and the Riverside County Planning Department. Verbal comment was received from John Matti (U.S. Geological Survey). Comments received have been discussed with those making the comment. No additional comments were received at the public hearing held by the State Mining and Geology Board on February 22, 1995.

Plates from FER-235 are not repeated in this supplement, however they should be referred to for identifying specific faults discussed herein. Figure 1 of this supplement is a general index map to the faults discussed.

SUMMARY OF COMMENTS (by quadrangle, west to east)

El Casco quadrangle:

Riverside County Geologist, Steven Kupferman has commented on the zoning of a short segment of the Banning Fault (Riverside County Planning Department, 1995). He notes that, in light of a majority of evidence that the Banning Fault is largely inactive west of Potrero Creek, the evidence suggesting activity of this western fault segment appears to be anomalous. Kupferman acknowledges that tectonically inactive faults may respond to movement on adjacent faults and he recommends that either the western Zone be eliminated or that other Banning Fault segments that have similar expression and are subject to the influence of nearby active faults also be zoned.

The California Department of Water Resources reviewed the same data that we had access to (Woodward-Clyde, 1993 and Rockwell, 1993) and concurred with our recommended zoning (California Department of Water Resources, 1995).

Beaumont quadrangle:

No comments have been received on the proposed zoning within this quadrangle, other than the implied suggestion that other portions of the Banning Fault might be considered subject to displacement sympathetic to activity on nearby active faults (Riverside County Planning Department, 1995, comment 4).

Through a drafting error, two short fault splays of the San Gorgonio Pass Fault Zone were not delineated within the proposed zone in the city of Banning.

Cabazon quadrangle:

Geologists at CalTech (California Institute of Technology, 1995) have commented that the northerly low-angle fault (Strand B, proposed for zoning) is interpreted by them to be inactive based on a lack of evidence for Holocene displacement, although they would "hesitate to suggest that it should not be zoned" and do not suggest a change in the zoning recommendation. However, if this strand *is* zoned, then they suggest that the low-angle fault system to the south in sections 2, 3 & 4 (Strand A) is more likely to be active than Strand B and should also be zoned. They agree with the depiction and zoning of several reverse-fault scarps south of the range front.

White Water quadrangle:

As on the Cabazon quadrangle, geologists at the California Institute of Technology (1995) have commented that the northerly low-angle fault (Strand B) is interpreted by them to be inactive based on a lack of geomorphic evidence, although they would "hesitate to suggest that it should not be zoned" and do not suggest a change in the zoning recommendation. They agree with the depiction and zoning of several reverse-fault scarps south of the range front.

Geologists at CalTech (California Institute of Technology, 1995) have also expressed some concern over faults not recommended for zoning in the vicinity of Alta Mesa, west of the Whitewater River. They believe that the fault that I refer to as the Garnet Hill Fault, cutting obliquely across the southwest side of Alta Mesa, is active and should be zoned. They believe that other strike-slip fault splays lie to the north of this fault and should also be reconsidered. They also note that we do not show other normal faults on Alta Mesa.

John Matti (personal communication, 1995) expressed similar concerns. He felt that there was insufficient evidence to show that the Garnet Hill Fault is not active. Regarding the faults on Alta Mesa, he felt that the westernmost north-trending feature, along the west side of Section 3, looked more like a fault than a gravitational feature, based on its linearity, length and vertical offset of the east-west mesa profile.

FIELD OBSERVATIONS

The Highland Springs scarp was rechecked on April 24, 1995. The small scarp remnant mentioned in the original FER-235 (Treiman, 1994, p.13) is as steep as 21° in some places. Other dissected slopes to the east (along the Highland Springs scarp) are as steep as 35° to 40°. Soil on the old surface above the scarp did not appear to have a high degree of rubification, supporting the late Pleistocene age assigned by Matti and others (1992).

The Garnet Hill fault was also rechecked on April 24. Scarps were generally subdued, however a minor drainage appeared to have a right offset of as much as 3-5m. A distinct vertical shear zone, trending N75°-85°W, was visible in the south side of the aqueduct cut at the shutter ridge.

DISCUSSION AND CONCLUSIONS (by quadrangle, west to east)

El Casco quadrangle:

Although it is difficult to understand or explain why this portion of the Banning Fault might be active, the evidence strongly suggests that there has been Holocene displacement (Rockwell, 1993; Treiman, 1994; Woodward-Clyde, 1993). The observation of horizontal striae on one of the fault surfaces argues against the possibility of mere secondary, non-tectonic response to other regional faults. Strike-slip displacement is supported by geomorphic evidence (right-offset drainages). Within Yucaipa Valley and westward the fault is poorly defined and there is no indication of Recent activity. Eastward (Beaumont quadrangle) the fault is discontinuously expressed, and lacks clear evidence of Holocene displacement. [See further discussion in the next section.]

Beaumont quadrangle:

In the Cherry Valley area the Banning Fault is obscured entirely by the combined fans of Little San Gorgonio Creek and Noble Creek. The only surface faults across the upper part of this fan complex appear as remnants of thrust fault scarps related to the San Gorgonio Pass Fault Zone and a fault trending southeast from Wildwood Canyon. Except for the northernmost of these (from Wildwood Canyon) the faults do not appear to have a strike-slip character and are unrelated to the Banning Fault. The thrust faults are expressed only in mid-Pleistocene fan deposits and are obscured by late-Pleistocene to early Holocene fan deposits. The Wildwood Canyon splay does not displace late-Pleistocene deposits in at least two localities (Treiman, 1994).

East of this fan complex the Banning Fault diverges as two strands, designated here Strand A and Strand B (after Matti and Morton, 1982). Strand A is clearly not active. Strand B, expressed only as a scarp across late-Pleistocene deposits (Qof) on the Banning Bench (and a possible contribution to the Highland Springs scarp, discussed below), shows no clear

evidence of Holocene activity and is not expressed in younger (though eroded) terrain east and west of the Banning Bench.

This review of data pertinent to the Banning Fault has also led to the reconsideration of an anomalous feature – a large escarpment just southeast of Highland Springs (Figure 2), referred to here as the Highland Springs scarp. This scarp marks the elevation of late-Pleistocene fan deposits (Qof) at least 50 meters above their possibly correlative deposits to the south. This is roughly five times the height of the scarp formed by Banning Strand B on the Banning Bench. This demonstrates that this scarp has been greatly accentuated by faulting more recent than that expressed across the Banning Bench. As we currently understand the faulting in the region this scarp development is probably related to the most westerly active portion of the San Gorgonio Pass Fault Zone. The Highland Springs scarp is about two-thirds the height of the escarpment along the toe of the Banning Bench where we have recommended zoning (CDMG, 1994a). Although we lack specific age data it is reasonable to assume, with this much post-Qof displacement, that faulting here has also continued into the Holocene. Matti and others (1992) interpret faulting to be transferred from the Highland Springs scarp to the toe of the Banning Bench along a northwest-trending strike-slip or tear fault. There is no direct surface evidence for the presence or location of this inferred tear fault. A westward continuation of this fault activity is not clear. As discussed above, the thrust fault scarp remnants in Cherry Valley are pre-Holocene. The "Wildwood Canyon" splay fault to the north may be more recently active than these thrust remnants, but it appears to be much less active than the Highland Springs scarp.

The two splays of the San Gorgonio Pass Fault that were not plotted on the Preliminary Earthquake Fault Zone map were described in FER-235 (Treiman, 1994, p.13 and Plate IIb). These faults are marked by offset drainages and aligned ridge ends.

Cabazon quadrangle:

At issue in this quadrangle is the relative activity of two strands of the Banning-San Gorgonio Pass fault complex, east of Millard Canyon. These strands are referred to as Banning Strands A and B (Treiman, 1994 – after Matti and Morton, 1982). Although geologic data currently available do not allow us to differentiate the activity of these two zones a reasonable distinction can be made. Strand A has almost no geomorphic expression whereas Strand B roughly coincides with a zone of oversteepened and eroding slopes. Additionally, where Strand B crosses Deep Canyon there is a clump of trees growing in the alluvium suggesting ponding of groundwater, but no notable vegetation at Strand A. These observations not only indicate the youth of Strand B relative to Strand A, but also suggest that Strand B is still active.

White Water quadrangle:

The relative ages of Banning Fault Strands A and B are even more apparent on the White Water quadrangle than on the Cabazon quadrangle. In addition to the zone of oversteepened and eroding slopes, Strand B is marked, east of Stubbe Canyon, by scarps, deflected drainages, saddles and sidehill benches (Treiman, 1994). Strand A is marked only by a highly eroded back-facing scarp.

The Garnet Hill Fault is a well-defined feature in the mid-Pleistocene Cabezon fanglomerate. It is marked by back-facing scarps and shutter ridges and some minor right and left-deflected drainages. A previously established Earthquake Fault Zone was proposed for removal based on the lack of evidence for Holocene displacement and the judgement that the faulting was specifically pre-Holocene, based on trenching by a consultant (Rasmussen and Associates, 1984a&b). A re-evaluation of the aerial photos and the trench data confirms the concerns of Matti (personal communication, 1995) and CalTech (California Institute of Technology, 1995) that the lack of Holocene activity is not clearly demonstrated. The scarps in the Cabezon fanglomerate indicate the presence of a fault that should be apparent in a trench, yet the trench logs show no significant shears in the fanglomerate. Either the shear surface is not easily visible in the coarse, moderately indurated fan deposits (a common problem), or the trenches may not have been extensive enough to cross the fault – the back-facing scarp, in an active erosional/depositional environment, may have migrated from the original fault-scarp location. Considering the location and orientation of this fault, continued right-lateral strike-slip displacement would not be surprising.

Among the various interpreted faults and landslides on the upper surface of Alta Mesa the north-south trending feature along the boundary between Sections 3 and 4 is the most likely structure to be a fault. As observed by Matti (personal communication, 1995), it is unlikely that landsliding would be responsible for the elevation change (approximately 50m) apparent in the east-west profile of the mesa surface. This feature has also been mapped with general agreement by various geologists, and most recently extended through at least one bedrock exposure by Richmond Wolf (California Institute of Technology, 1993, unpublished mapping). This feature is probably tectonic in origin and, considering its location, may be active.

RECOMMENDATIONS (by quadrangle, west to east)

El Casco quadrangle:

In the northeast portion of this quadrangle the Banning Fault is well-defined and sufficiently active. **The Preliminary Earthquake Fault Zone (CDMG, 1994c) for the Banning Fault should be retained as proposed.**

Beaumont quadrangle:

The Banning Fault is not well defined in the western part of this quadrangle. Where it is reasonably well defined it is not sufficiently active, except perhaps where it has been overprinted with the activity of the San Gorgonio Pass Fault Zone (east of Highland Springs). **The Banning Fault should not be zoned within this quadrangle.**

The Highland Springs scarp (Section 25) is probably largely a product of movement on the San Gorgonio Pass Fault Zone with significant vertical displacement of late-Pleistocene deposits (approximately 50m), and **should be included within a new Earthquake Fault Zone (Figure 2).** The fault location is based partly on the unpublished mapping of Matti and Morton (1993) and partly on aerial photo interpretation.

Due to a drafting error, two short fault splays in the city of Banning were not delineated on the Preliminary Earthquake Fault Zone map (CDMG, 1994a). These splays are within the proposed zone. **The two short faults splays in Banning should be added within the Earthquake Fault Zone (Figure 2). The zone boundary should be adjusted to maintain an appropriate distance from the fault.**

Cabazon quadrangle:

No changes are recommended to the proposed zones (CDMG, 1994b) in this quadrangle.

White Water quadrangle:

The recommendation of FER-235 (Treiman, 1994; as implemented in the Preliminary Earthquake Fault Zone map - CDMG, 1994d) to withdraw all zones on Alta Mesa, except for the Banning Fault, should be reversed. The Garnet Hill Fault and a splay to the northeast are mostly well-defined. They display geomorphic features suggestive of activity and, considering their location between two active faults, there is insufficient data to justify their withdrawal from the existing zone. **The existing Earthquake Fault Zone along the Garnet Hill Fault should be modified to accommodate recent mapping and current zoning practice. The north-south trending Earthquake Fault Zone along the boundary of Sections**

3 and 4 should be extended into Section 10 and modified to reflect recent mapping and current zoning practice. These changes are shown on Figure 3. This additional zoning is based largely on the unpublished mapping of Morton and Matti (1993b) with slight additions and modifications from aerial photo interpretation. The north-south trending fault is extended to the southeast based on unpublished mapping by Wolf (1993). The southerly-trending zone through the middle of Section 3 should remain deleted.

References on zone maps (CDMG, 1994 a-d):

The reference to Matti, Morton and Cox (1992) on the Earthquake Fault Zone maps should be amended so that the parenthetical statement reads:

(modified by unpublished U.S. Geological Survey mapping as shown in Treiman, 1994)

Report reviewed and approved William A. Bryant May 24, 1995

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REFERENCES

(* - unpublished consultants reports: [AP#] or [C#] designation indicates report is on file with CDMG; [GR#] indicates report is on file with Riverside County)

California Department of Water Resources, 1995, unpublished letter from Director David N. Kennedy to the State Mining and Geology Board dated March 2, 1995, 1p.

California Institute of Technology, 1995, unpublished letter from James A. Spotila to Earl W. Hart on behalf of Kerry Sieh, dated February 6, 1995, 3p.

CDMG, 1994a, Preliminary review map of Earthquake Fault Zones, Beaumont quadrangle: California Division of Mines and Geology, December 1, 1994, 1:24,000.

CDMG, 1994b, Preliminary review map of Earthquake Fault Zones, Cabazon quadrangle (revised): California Division of Mines and Geology, December 1, 1994, 1:24,000.

CDMG, 1994c, Preliminary review map of Earthquake Fault Zones, El Casco quadrangle (revised): California Division of Mines and Geology, December 1, 1994, 1:24,000.

CDMG, 1994d, Preliminary review map of Earthquake Fault Zones, White Water quadrangle (revised): California Division of Mines and Geology, December 1, 1994, 1:24,000.

Hart, E.W., 1994, Fault-rupture hazard zones in California: California Department of Conservation, Division of Mines and Geology Special Publication 42, Revised 1994, 34p.

Matti, J.C., and Morton, D.M., 1982, (abstract), Geologic history of the Banning Fault Zone, southern California: Geological Society of America, cordilleran Section Meeting, Abstracts With Programs, v.14, no.4, p.184.

Matti, J.C., and Morton, D.M., 1993 (in preparation), Geologic map of the Beaumont 7.5' quadrangle, Riverside County, California: U.S.Geological Survey, unpublished mapping, 1:24,000.

Matti, J.C., Morton, D.M., and Cox, B.F., 1992, The San Andreas Fault system in the vicinity of the central Transverse Ranges Province, southern California: U.S. Geological Survey Open-File Report 92-354, 50p., map scale - 1:250,000.

Morton, D.M., and Matti, J.C., 1993b (in preparation), Geologic map of the Whitewater 7.5' quadrangle, Riverside County, California: U.S.Geological Survey, unpublished mapping, 1:24,000.

* Rasmussen, G.S., & Associates, 1984a, Preliminary engineering geology investigation of proposed wind energy project, portion of sections 5 and 9, T2S, R3E, SBB&M, west of Alta Mesa, San Gorgonio Pass, Riverside County, California: unpublished consultant's report, Project No. 2016, May 14, 1984. [GR303; C820]

* Rasmussen, G.S., & Associates, 1984b, Addendum to our preliminary engineering geology investigation of proposed wind energy project, San Gorgonio Pass, Riverside County, California: unpublished consultant's report, Project No. 2016-2, June 28, 1984. [GR303; C820]

Riverside County Planning Department, 1995, unpublished letter from County Geologist, Steven A. Kupferman to the State Mining and Geology Board, dated March 1, 1995, 2p.

Rockwell, T., 1993, letter report to Woodward-Clyde Consultants dated 15 January, 1993: included as Appendix A in Woodward-Clyde Consultants (1993), 3p.

Treiman, J.A., 1994, The San Gorgonio Pass, Banning and related faults, Riverside County, California: California Division of Mines and Geology, Fault Evaluation Report FER-235, September 27, 1994 (unpublished).

Wolf, Richmond, 1993, unpublished mapping of the Garnet Hill, Banning and related faults on the White Water and Desert Hot Springs 7.5-minute quadrangles: California Institute of Technology, 1:24,000. [mapping from White Water quadrangle plotted on Plate Id, Treiman, 1994]

* Woodward-Clyde Consultants, 1993, Feasibility-level geologic/geotechnical investigations for Upper Singleton Canyon Reservoir, Riverside County, California: unpublished consultant's report, project no. 924G094A, April 1993. [C824]

AERIAL PHOTOGRAPHS USED

U.S. Department of Agriculture
scale - 1:20,000 b/w 9x9

AXM - 1K -	105 to 106	8/22/53
AXM - 4K -	97 to 99	10/20/53
AXM - 8K -	142 to 144	10/21/53
AXM -12K -	39 to 41	11/25/53
	55 to 56	11/25/53
	129 to 130	11/25/53
	144 to 145	11/25/53
AXM -15K -	100 to 102	12/31/53

Riverside County Flood Control District

1/30/61	1:12,000	b/w	9x9:	frames 36 to 37

Figure 1

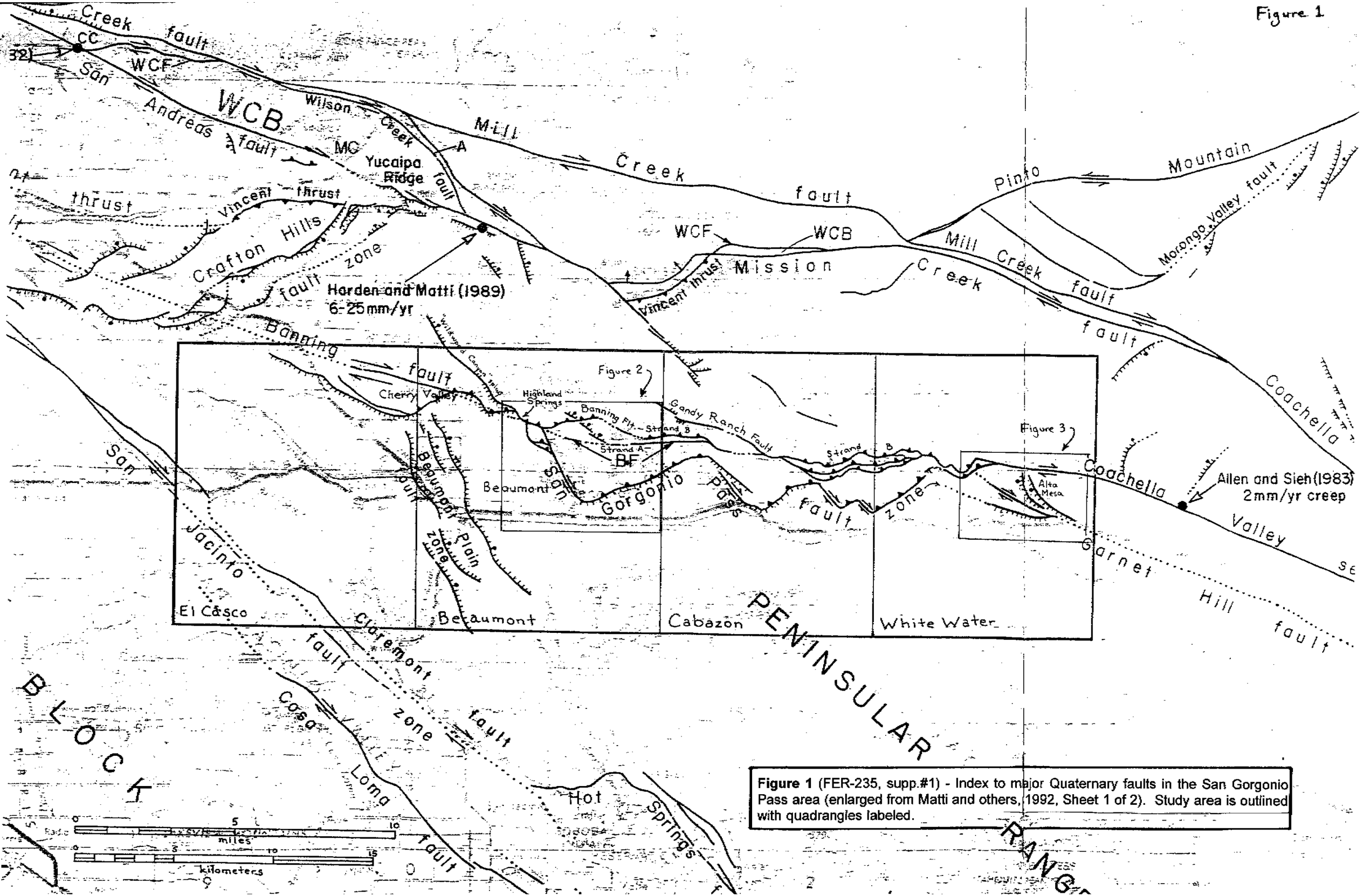

Figure 1 (FER-235, supp.#1) - Index to major Quaternary faults in the San Gorgonio Pass area (enlarged from Matti and others, 1992, Sheet 1 of 2). Study area is outlined with quadrangles labeled.

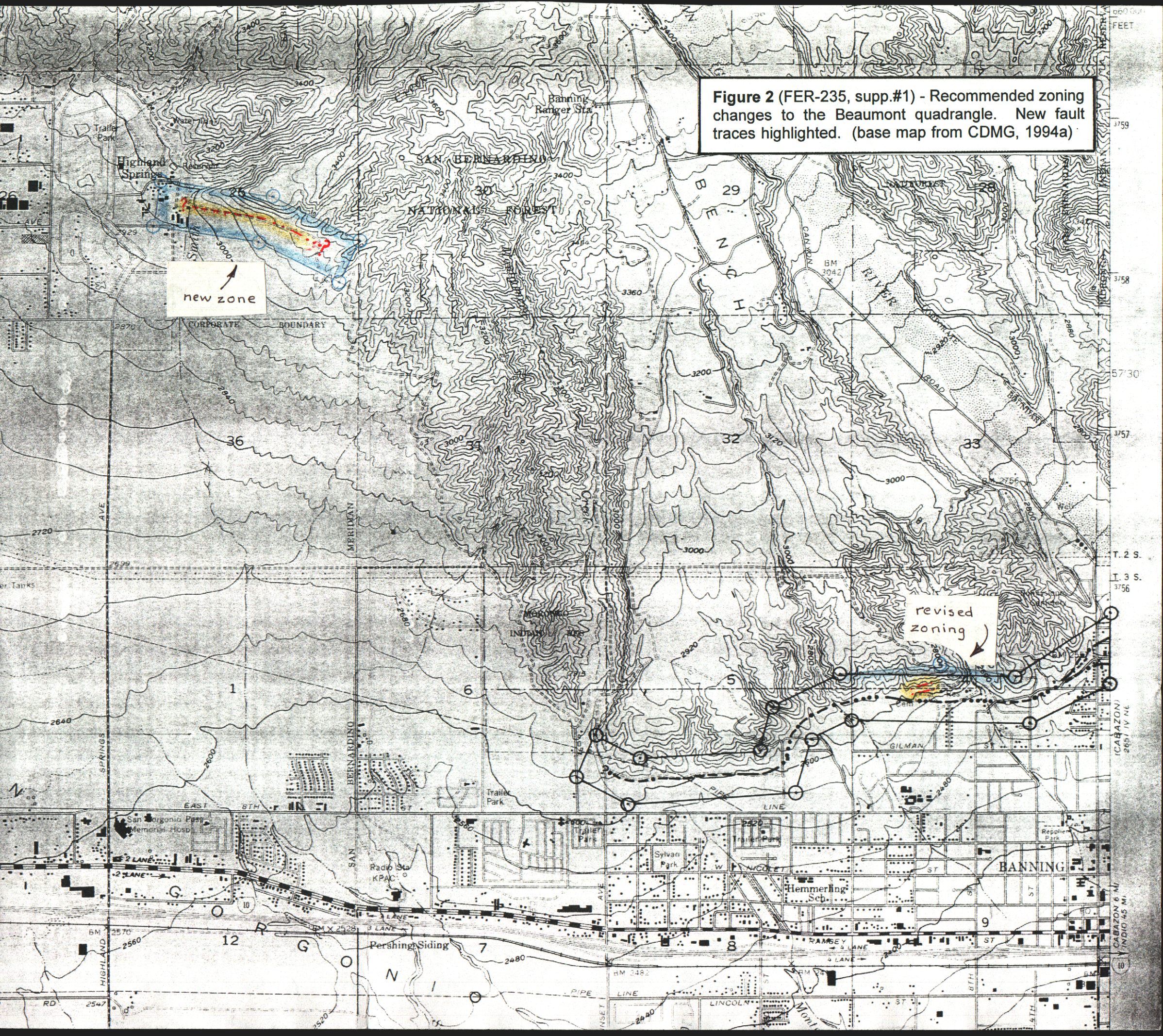

Figure 2 (FER-235, supp.#1) - Recommended zoning changes to the Beaumont quadrangle. New fault traces highlighted. (base map from CDMG, 1994a)